REPORT DOCUMENTATION PAGE

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1. REPORT DATE (DD-MM-YYYY)	2. REPORT TYPE	3. DATES COVERED (From - To)
14-08-2015	Final Report	1-Aug-2013 - 31-Jul-2015

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Collaboration of Miniature Multi-Modal Mobile Smart Robots over a Network

5a. CONTRACT NUMBER
W911NF-13-1-0286

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER
611103

6. AUTHORS
Asok Ray

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAMES AND ADDRESSES
Pennsylvania State University
Office of Sponsored Programs
110 Technology Center Building
University Park, PA 16802 -7000

8. PERFORMING ORGANIZATION REPORT NUMBER

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U.S. Army Research Office
P.O. Box 12211
Research Triangle Park, NC 27709-2211

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14. ABSTRACT
The Pennsylvania State University has developed the Networked Robotic Systems Laboratory (NRSL) under several Defense University
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failures in sensor-network-based miniature multimodal mobile robots and electromechanical systems.

15. SUBJECT TERMS
Robots, Computer Network

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	15. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Asok Ray
UU	UU	UU	UU		19b. TELEPHONE NUMBER 814-865-6377

Report Title

Collaboration of Miniature Multi-Modal Mobile Smart Robots over a Network

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Enter List of papers submitted or published that acknowledge ARO support from the start of the project to the date of this printing. List the papers, including journal references, in the following categories:

(a) Papers published in peer-reviewed journals (N/A for none)

Received Paper

TOTAL:

Number of Papers published in peer-reviewed journals:

(b) Papers published in non-peer-reviewed journals (N/A for none)

Received Paper

TOTAL:

Number of Papers published in non peer-reviewed journals:

(c) Presentations

Number of Presentations: 0.00

Non Peer-Reviewed Conference Proceeding publications (other than abstracts):

Received Paper

TOTAL:

Number of Non Peer-Reviewed Conference Proceeding publications (other than abstracts):

Peer-Reviewed Conference Proceeding publications (other than abstracts):

Received Paper

TOTAL:

Number of Peer-Reviewed Conference Proceeding publications (other than abstracts):

(d) Manuscripts

Received Paper

TOTAL:

Number of Manuscripts:

Books

Received Book

TOTAL:

Received Book Chapter

TOTAL:

Patents Submitted

Patents Awarded

Awards

None

Graduate Students

NAME	PERCENT_SUPPORTED

FTE Equivalent:
Total Number:

Names of Post Doctorates

NAME	PERCENT_SUPPORTED

FTE Equivalent:
Total Number:

Names of Faculty Supported

NAME	PERCENT_SUPPORTED	National Academy Member
Asok Ray	0.00	
FTE Equivalent:	**0.00**	
Total Number:	**1**	

Names of Under Graduate students supported

NAME	PERCENT_SUPPORTED
FTE Equivalent:	
Total Number:	

Student Metrics

This section only applies to graduating undergraduates supported by this agreement in this reporting period

The number of undergraduates funded by this agreement who graduated during this period: 0.00

The number of undergraduates funded by this agreement who graduated during this period with a degree in science, mathematics, engineering, or technology fields:..... 0.00

The number of undergraduates funded by your agreement who graduated during this period and will continue to pursue a graduate or Ph.D. degree in science, mathematics, engineering, or technology fields:..... 0.00

Number of graduating undergraduates who achieved a 3.5 GPA to 4.0 (4.0 max scale):..... 0.00

Number of graduating undergraduates funded by a DoD funded Center of Excellence grant for Education, Research and Engineering:..... 0.00

The number of undergraduates funded by your agreement who graduated during this period and intend to work for the Department of Defense 0.00

The number of undergraduates funded by your agreement who graduated during this period and will receive scholarships or fellowships for further studies in science, mathematics, engineering or technology fields: 0.00

Names of Personnel receiving masters degrees

NAME
Total Number:

Names of personnel receiving PHDs

NAME
Total Number:

Names of other research staff

NAME	PERCENT_SUPPORTED
Kevin Fisher	0.10
FTE Equivalent:	**0.10**
Total Number:	**1**

Sub Contractors (DD882)

Inventions (DD882)

Scientific Progress

Supported the construction of laboratory experiments for several DoD projects

Technology Transfer

None

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Subtitle: None

5. FUNDING NUMBERS
Research Agreement No. W911NF-13-1-0286

6. AUTHOR(S) Asok Ray

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
The Pennsylvania State University, University Park, PA 16802

8. PERFORMING ORGANIZATION REPORT NUMBER DURIP 2013/Ray

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U. S. Army Research Office
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Dr. Liyi Dai
U. S. Army Research Office
P.O. Box 12211
Research Triangle Park, NC 27709-2211

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12 a. DISTRIBUTION / AVAILABILITY STATEMENT
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12 b. DISTRIBUTION CODE
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14. SUBJECT TERMS			15. NUMBER OF PAGES 12
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Final Report
on

2013 Defense University Research Instrumentation Program

Collaboration of Miniature Multi-Modal Mobile Smart Robots over a Network

Research Agreement No. W911NF-13-1-0286

Starting Date:	August 01, 2013
End date:	July 31, 2015
Recipient University:	The Pennsylvania State University (PSU)
Program Manager:	Dr. Liyi Dai, Army Research Office
Principal Investigator:	Professor Asok Ray, Penn State

July 31, 2015

Introduction

The procured equipments have been used to construct electromechanical, robotic, and electronic apparatuses in the Networked Robotic Systems Laboratory (NRSL) in conjunction with other laboratories and research centers at Pennsylvania State University. At present, the major role of NRSL is to support the several other research laboratories and major interdisciplinary projects. An example is the Multidisciplinary University Research Initiative **(**MURI) project under the ARO Grant No. W911NF-07-1-0376 that started in June 2007 and is scheduled to be completed in June 2014. Extensive experimental research is being conducted to validate the theoretical results, for which special-purpose laboratory apparatuses have been and also are being constructed. The following two laboratories have been enhanced with this DURIP grant.

- Networked Robotic Systems Laboratory
- Electromechanical Systems Laboratory

***The Networked Robotic Systems Laboratory* (NRSL)** emulates multi-level battlefield Command & Control (C^2) systems. It is realized through integration of several computer-controlled mobile robots at the lowest level, computer-controlled coordinators at the intermediate level, and the simulated Commander at the top level. The robots represent various mobile platforms (with on-board sensing capabilities) at the battle front. The information from these robots is communicated via wireless transmission to the Coordinators. The battlefront scenarios are emulated at the top level based on the real-time processed information from the Coordinators. The Commander computer makes decisions based on this information and issues commands to the Coordinators that, in turn, transmit instructions to the individual robots under their control. The challenge here is to formulate and validate decision and control policies for failure accommodation and mitigation in the uncertain operating environments with partial information being available from sensors and other sources.

The Electromechanical Systems Laboratory (EMSL) is a combination of (interacting) electronic, electro-mechanical, electro-hydraulic, and mechanical systems controlled by real-time networked computer systems. The goal is to validate engineering and scientific theories of integrated control, communication, and computing in large-scale systems, where the complexity is hidden during nominal operations and may only become acutely conspicuous when contributing to rare cascading failures. Laboratory apparatuses have been designed and fabricated for experimental research to address fundamental aspects of fatigue crack initiation, multi-degree-of-freedom mechanical devices, electric motors, and active electronic circuits.

The following paragraphs outline the structure of NRSL and its role in experimental validation of the analytical research under several DoD-sponsored research projects. The procured instrumentation has been used in the construction of NRSL as follows:

- The laboratory has the capability of simulating hybrid (i.e., a combination of continuously varying and discrete-event) dynamics and control systems to optimize the of the mission performance of subsystems distributed among different operating units.
- The modular design of the Laboratory allows separation of plant operations, control modules and their event/action interfaces.
- The laboratory is scalable with respect to both horizontal (i.e., new nodes) and vertical (i.e., new control hierarchies) reconfigurations. This ensures flexibility of the scaled system.
- The laboratory configuration supports control of sub-networks with a flexible (e.g., hierarchical and non-hierarchical) topology.
- Although it may not be feasible to incorporate complexities in the actual operations of weapon systems and platforms within the Laboratory, its hardware-in-the-loop feature adds considerably to the realism of simulation. To this end, in addition to significant computational capability, the laboratory interacts in real time with a number of networked autonomous mobile robots and will have interfaces with a damage sensing and damage emulation apparatus. Robotic platforms will be used to serve as agents (i.e., an entity of intelligent machine(s) that automates some of the tasks regarded as mundane, dangerous, or laborious for a human being).

- The laboratory has the capability to demonstrate supervisory behavior-based control of discrete-event multi-agent systems that emulate operations of weapon systems in the real-time complex environments of battlefield.

Application to Defense Requirements

The research in the laboratory addresses fundamentally new approaches to designing and operating fault-tolerant sensing and decision systems for multiple concurrent applications. Specifically, the research will provide a scientific and technical base for dynamic utilization of redundancy through information-theoretic analysis depending on the instantaneous state of components. The ultimate benefits of this research are to enhance operational reliability and preparedness of the U.S. military.

From the perspectives of health management of plant structures and its fleet-wide implementation in the battlefield environment, major benefits of the proposed research are enhanced safety, reliability, and availability; reduction of the life cycle cost by optimization of the operation and maintenance schedule; and reduced need for skilled technicians for on-site maintenance.

Estimated Useful Life of the Equipment

The estimated useful life of different categories of equipment is delineated below:

- *Complex Systems Simulation Equipment*: The average life of equipment in this category is estimated to be about ten years because the technology in this field is evolving at rapid pace.
- *Electromechanical, Robotics, and Visualization Equipment*: The average life of equipment in this category of robotic equipment is estimated to be about twenty years because the technology in this field is moderately mature and is evolving at medium pace

Property Report

All equipment procured under the Research Agreement No. W911NF-09-1-0252 vests with Pennsylvania State University that is the sole recipient of this DURIP award.

Budget Report

The total budget of this research equipment project (Grant No. W911NF-13-1-0286) is **$200,000.00**, which is completely funded by the DoD. The current expenses for equipment purchase has been approximately $152,000. The remaining amount of approximately $ 48,000 has been used for supporting technicians for laboratory construction.

The summary and details of both incurred expenses and encumbered expenses are provided in the next pages. The excess amount (i.e., the overspent amount in parentheses) will be absorbed in other grants of the Principal Investigator.

Details, Both Actual and Encumbrances, to Date

0401551 UP70RU0 DA DURIP SMART ROBOTS

Project Director: A. RAY

Cost Center: None

0069 *U.S. GOVT SPECIAL CONTRACTS*

Actual	2/3/2014	09810959		ROCR	9810959	$9,720.49
Actual	2/7/2014	09817732		ROCR	9817732	$1,773.81
Actual	4/7/2014	09879351		ROCR	9879351	$2,715.97
Actual	4/7/2014	09879361		ROCR	9879361	$13,426.30
Actual	5/13/2014	09924242		ROCR	9924242	$34,823.96
Actual	1/14/2015	10225664UP		ROCR	10225664	$4,939.26
Actual	1/22/2015	10228503UP		ROCR	10228503	$3,029.03
Actual	3/3/2015	10274906UP		ROCR	10274906	$15,427.76
Actual	3/12/2015	10282402UP		ROCR	10282402	$30,105.29
Actual	4/21/2015	10323551UP		ROCR	10323551	$4,960.30
Actual	5/8/2015	10343062UP		ROCR	10343062	$4,705.64
Actual	6/3/2015	10375018UP		ROCR	10375018	$16,094.93
Actual	7/6/2015	10418595UP		ROCR	10418595	$29,658.61
	Total For U.S. GOVT SPECIAL CONTRA				**$171,381.35**	

0124 *FT2-ACADEMIC*

Actual	6/30/2015	914796595	LI	PAYS		$3,493.50
Actual	6/30/2015	902012245	FU	PAYS		$2,989.50
Actual	6/30/2015	986442265	SARKAR	PAYS		$3,493.50
Encumbrance	7/31/2015	902012245	FU	PAYS		$2,989.50
Encumbrance	7/31/2015	986442265	SARKAR	PAYS		$3,493.50
Encumbrance	7/31/2015	914796595	LI	PAYS		$3,493.50
	Total For FT2-ACADEMIC :				**$19,953.00**	

0176 *FT1-STAFF NON-EXEMPT*

Actual	2/16/2015	914459433		PAYT	10248299	$819.28
Actual	3/16/2015	914459433		PAYT	10274594	$1,062.85
Actual	4/29/2015	914459433		PAYT	10323151	$1,151.42
Actual	5/19/2015	914459433	KEVIN FISHE	PAYT	10339236	$989.82
Actual	6/22/2015	914459433		PAYT	10392776	$730.71
	Total For FT1-STAFF NON-EXEMPT				**$4,754.08**	

0206 *WAGE STAFF NONEXEMPT*

Actual	1/23/2015	996306626		DSTW		$740.00
Actual	2/6/2015	996306626		DSTW		$740.00
Actual	2/20/2015	996306626		DSTW		$740.00
Actual	3/6/2015	996306626		DSTW		$740.00
Actual	3/20/2015	996306626		DSTW		$740.00
Actual	4/3/2015	996306626		DSTW		$740.00
Actual	4/17/2015	996306626		DSTW		$740.00
Actual	5/1/2015	996306626		DSTW		$740.00
Actual	5/15/2015	996306626		DSTW		$740.00
Actual	5/29/2015	996306626		DSTW		$740.00

Actual	6/12/2015	996306626		DSTW			$740.00
Actual	6/26/2015	996306626		DSTW			$740.00
Actual	7/10/2015	996306626		DSTW			$740.00
	Total For WAGE STAFF NONEXEMPT				**$9,620.00**		

0216 NON-EXEMPT STUDENT WAGES

Actual	4/17/2015	907773343		DSTW			$800.00
Actual	5/1/2015	907773343		DSTW			$210.00
Actual	5/15/2015	907773343		DSTW			$200.00
	Total For NON-EXEMPT STUDENT WAG				**$1,210.00**		

0301 STATIONERY&OFFICE SUPPLIES

Actual	10/15/2013	E13023479 End date: 7/31/2014	CDW-G	EBUY			$285.03
Encumbrance	4/30/2014		ROBOTICS LA	JVDP		9905241	($285.03)
Actual	5/1/2014	09905241	ROBOTICS LA	JVDP		9905241	($285.03)
Encumbrance	5/1/2014	09905241	ROBOTICS LA	JVDP		9905241	$285.03
	Total For STATIONERY&OFFICE SUPPL				**$0.00**		

0303 LABORATORY SUPPLIES

Encumbrance	12/18/2013	PR45835115-END DATE: 7/31/2014	VICON DENV	PURC			$373.00
Actual	2/26/2014	VICON PR45835115-END DATE: 7/31/2014	VICON DENV	PURC			$373.00
Encumbrance	2/26/2014	PO ATFO PR45835115-END DATE: 7/31/2014	VICON DENV	PURC			($373.00)
Encumbrance	4/30/2014		ROBOTICS LA	JVDP		9905241	($373.00)
Actual	5/1/2014	09905241	ROBOTICS LA	JVDP		9905241	($373.00)
Encumbrance	5/1/2014	09905241	ROBOTICS LA	JVDP		9905241	$373.00
Actual	8/1/2014	P0043803132 BLUETOOTH USB RADIOS	IROBOT	RPCC			$90.63
Actual	8/11/2014	10025784 NEED TO USE 705	CORRECT OB	JVDP		10025784	($90.63)
Actual	5/12/2015	P004554169SUPPLIES FOR THE ROBOTS LAB	AMAZON	RPCC			$428.63
	Total For LABORATORY SUPPLIES				**$428.63**		

0322 POSTAGE AND MAILINGS

Actual	4/3/2015	DSM124712 DSM124712		DBMS			$5.18
	Total For POSTAGE AND MAILINGS				**$5.18**		

0331 PREPD REG-CONF & SEM

Actual	1/19/2015	LEE LEE,J-LOSANGELES,CA-12/14-19/	LEE,J-LOSAN	ERSS			$480.00
Actual	1/28/2015	10225549	LEE.J-LOS AN	JVDP		10225549	($480.00)
	Total For PREPD REG-CONF & SEM				**$0.00**		

0337 OUT-OF-STATE TRAVEL

Actual	1/19/2015	LEE LEE,J-LOSANGELES,CA-12/14-19/	LEE,J-LOSAN	ERSS			$2,227.03
Actual	1/28/2015	10225549	LEE.J-LOS AN	JVDP		10225549	($2,227.03)
	Total For OUT-OF-STATE TRAVEL				**$0.00**		

0431 SAL FRINGE BENEFITS

Actual	2/16/2015	FO:FRNGSAL		JVFO			$294.94
Actual	3/16/2015	FO:FRNGSAL		JVFO			$382.63
Actual	4/29/2015	FO:FRNGSAL		JVFO			$414.51
Actual	5/19/2015	FO:FRNGSAL		JVFO			$356.34

Actual	6/22/2015	FO:FRNGSAL		JVFO			$263.06
	Total For SAL FRINGE BENEFITS				**$1,711.48**		

0432 WAGE FRINGE BENEFITS

Actual	1/20/2015	FO:FRNGWAG		JVFO			$57.72
Actual	2/3/2015	FO:FRNGWAG		JVFO			$57.72
Actual	2/17/2015	FO:FRNGWAG		JVFO			$57.72
Actual	3/3/2015	FO:FRNGWAG		JVFO			$57.72
Actual	3/17/2015	FO:FRNGWAG		JVFO			$57.72
Actual	4/1/2015	FO:FRNGWAG		JVFO			$57.72
Actual	4/14/2015	FO:FRNGWAG		JVFO			$57.72
Actual	5/2/2015	FO:FRNGWAG		JVFO			$57.72
Actual	5/12/2015	FO:FRNGWAG		JVFO			$57.72
Actual	5/22/2015	FO:FRNGWAG		JVFO			$57.72
Actual	6/9/2015	FO:FRNGWAG		JVFO			$57.72
Actual	6/23/2015	FO:FRNGWAG		JVFO			$57.72
Actual	6/30/2015	FO:FRNGWAG		JVFO			$778.16
Actual	6/30/2015	FO:FRNGWAG		JVFO			$57.72
	Total For WAGE FRINGE BENEFITS				**$1,528.52**		

0435 STUDENT FRINGE

Actual	4/14/2015	FO:FRNGSTU		JVFO			$0.80
Actual	5/2/2015	FO:FRNGSTU		JVFO			$0.21
Actual	5/12/2015	FO:FRNGSTU		JVFO			$0.20
	Total For STUDENT FRINGE :				**$1.21**		

0452 SOFTWARE

Encumbrance	12/18/2013	PR45835115-END DATE: 7/31/2014	VICON DENV	PURC			$5,008.00
Actual	12/20/2013	09743552 MOVED FROM DEPT GENERAL	MATLAB LICE	JVDP		9743552	$562.50
Actual	3/10/2014	VICON PR45835115-END DATE: 7/31/2014	VICON DENV	PURC			$5,008.00
Encumbrance	3/10/2014	PO ATFO PR45835115-END DATE: 7/31/2014	VICON DENV	PURC			($5,008.00)
Encumbrance	4/30/2014		ROBOTICS LA	JVDP		9905241	($5,570.50)
Encumbrance	5/1/2014	09905241	ROBOTICS LA	JVDP		9905241	$5,570.50
Actual	5/1/2014	09905241	ROBOTICS LA	JVDP		9905241	($5,570.50)
Actual	11/19/2014	10148831 E14-029328	MATLAB REN	JVDP		10148831	$624.73
	Total For SOFTWARE :				**$624.73**		

0459 NON-COMPUTER EQUIP UNDER $5000

Actual	1/17/2014	09788279 COPTERS/TRANSMITTERS/OSDSYSTEM	3D ROBOTICS	SRFC		9788279	$8,980.80
Encumbrance	4/30/2014		ROBOTICS LA	JVDP		9905241	($8,980.80)
Actual	5/1/2014	09905241	ROBOTICS LA	JVDP		9905241	($8,980.80)
Encumbrance	5/1/2014	09905241	ROBOTICS LA	JVDP		9905241	$8,980.80
Encumbrance	7/1/2015	PR63610296	RAY ROBOTI	PURC			$1,750.00
	Total For NON-COMPUTER EQUIP UND				**$1,750.00**		

0480 COMPUTERS $4999 AND LESS

Actual	10/8/2013	E13018610 End date: 7/31/2014	Dell	EBUY			$4,771.12
Actual	10/15/2013	E13023479 End date: 7/31/2014	CDW-G	EBUY			$1,445.85
Actual	12/16/2013	E13036836 end date: 7/31/2014	Dell	EBUY			$623.99

Actual	2/13/2014	E13047250 End date: 7/31/2014	Robot compute	EBUY		$1,443.70
Encumbrance	4/30/2014		ROBOTICS LA	JVDP	9905241	($8,284.66)
Actual	5/1/2014	09905241	ROBOTICS LA	JVDP	9905241	($8,284.66)
Encumbrance	5/1/2014	09905241	ROBOTICS LA	JVDP	9905241	$8,284.66
	Total For COMPUTERS $4999 AND LES				**$0.00**	

0705 FABRICATED CAP EQUIP

Encumbrance	2/26/2014	PR47949556-END DATE: 7/31/14	LAB COMPUT	PURC		$18,088.35
Actual	4/16/2014	P004313736TWO KINIVO BLUETOOTH USB ADAPT	AMAZON.CO	RPCC		$41.23
Actual	4/16/2014	P004317270VITON FLUOROELASTOMER O RINGS	MCMASTER C	RPCC		$62.06
Actual	4/16/2014	P004317271WEB SMART 24-PORT SWITCH/PORTS	AMAZON.CO	RPCC		$400.98
Actual	4/22/2014	P004318410O RINGS	MCMASTER C	RPCC		$53.26
Actual	4/29/2014	P004327707RETURN OF O RINGS/P#4317270	MCMASTER C	RPCC		($62.06)
Actual	4/29/2014	P004322886SMALL GROUND ROBOTS	SPARK FUN E	RPCC		$99.51
Encumbrance	4/30/2014	CORRECT OBJ CODE TO 705	ROBOTICS LA	JVDP	9905241	$50,830.99
Encumbrance	5/1/2014	09905241 CORRECT OBJ CODE TO 705	ROBOTICS LA	JVDP	9905241	($50,830.99)
Actual	5/1/2014	09905241 CORRECT OBJ CODE TO 705	ROBOTICS LA	JVDP	9905241	$50,830.99
Encumbrance	7/12/2014	CO ENCUM	LAB COMPUT	PURC		$18,088.35
Encumbrance	7/12/2014	CO RLSE	LAB COMPUT	PURC		($18,088.35)
Actual	7/14/2014	P004367701TRIPPLITE INTERNET BACK UP	AMAZON.CO	RPCC		$67.73
Actual	7/14/2014	P004368392TRIPP LITE INTERNET UPS DESKT	AMAZON	RPCC		$67.74
Encumbrance	7/30/2014	PR52760782	ALICONA CO	PURC		$3,600.00
Actual	8/1/2014	P004382620TAX CREDIT FOR P#4380313	I ROBOT	RPCC		($5.13)
Actual	8/11/2014	10025784 NEED TO USE 705 PI # 14-18	CORRECT OB	JVDP	10025784	$90.63
Encumbrance	9/4/2014	PR53864328	AEROTECH I	PURC		$14,166.00
Actual	9/8/2014	P004403442USB BLASTER CABLE	DIGI KEY CO	RPCC		$58.02
Encumbrance	10/9/2014	PR54837529	LAB EQUIPME	PURC		$12,523.20
Actual	10/14/2014	P004424885NYLON CONNECTORS MALE/FEMALE	PAYPAL U HO	RPCC		$84.85
Actual	10/14/2014	P004424886SRDUINO PROTOSHIELD KIT/WI FI	SPARK FUN E	RPCC		$606.00
Actual	10/19/2014	P004428301APC SMART UPS SYSTEM	AMAZON	RPCC		$339.99
Actual	10/19/2014	P004428302APC SMART UPS SYSTEM	AMAZON	RPCC		$339.99
Encumbrance	10/27/2014	PO ATFO PR53864328	AEROTECH I	PURC		($14,166.00)
Actual	10/27/2014	AEROTECH PR53864328	AEROTECH I	PURC		$14,324.00
Encumbrance	10/27/2014	UNENC INCR	AEROTECH I	PURC		($158.00)
Encumbrance	10/27/2014	A INCREASE	AEROTECH I	PURC		$158.00
Actual	11/2/2014	P004438193ALUMINUM PRECISION SHEET	MCMASTER C	RPCC		$120.06
Actual	11/14/2014	P004448690DCDC USB INTELLIGENT DC-DC	ITUNER NET	RPCC		$1,558.80

Encumbrance	11/14/2014	PR56283328	FABRICATED	PURC		$2,818.11
Actual	11/17/2014	P004447029SEAGATE BARRACUDA/DR RAY	AMAZON	RPCC		$416.20
Encumbrance	12/4/2014	PO ATFO PR54837529	LAB EQUIPME	PURC		($12,523.20)
Actual	12/4/2014	DECAGON DEPR54837529	LAB EQUIPME	PURC		$12,523.20
Encumbrance	12/10/2014	A INCREASE	FABRICATED	PURC		$48.16
Actual	12/10/2014	DIGI KEY PR56283328	FABRICATED	PURC		$2,866.27
Actual	12/10/2014	P004460686VARIOUS COLORS OF DUCT TAPE	AMAZON	RPCC		$38.29
Encumbrance	12/10/2014	PO ATFO PR56283328	FABRICATED	PURC		($2,818.11)
Encumbrance	12/10/2014	UNENC INCR	FABRICATED	PURC		($48.16)
Encumbrance	12/15/2014	PR57175101	MICROWAY	PURC		$9,619.00
Actual	1/22/2015	MICROWAY PR57175101	MICROWAY	PURC		$9,619.00
Encumbrance	1/22/2015	PO ATFO PR57175101	MICROWAY	PURC		($9,619.00)
Encumbrance	1/23/2015	PO ATFO PR47949556-END DATE: 7/31/14	LAB COMPUT	PURC		($18,050.30)
Actual	1/23/2015	P004482139DISPLAY PORT TO HDMI CABLE/ADA	AMAZON	RPCC		$39.96
Actual	1/23/2015	DELL MARKEPR47949556-END DATE: 7/31/14	LAB COMPUT	PURC		$18,050.30
Actual	1/23/2015	P004482140PEARL MARKERS/BASES	VICON	RPCC		$436.00
Encumbrance	1/23/2015	PO ATFO PR47949556-END DATE: 7/31/14	LAB COMPUT	PURC		($38.05)
Encumbrance	1/23/2015	A INCREASE	LAB COMPUT	PURC		$0.01
Encumbrance	1/23/2015	UNENC INCR	LAB COMPUT	PURC		($0.01)
Actual	1/23/2015	DELL MARKEPR47949556-END DATE: 7/31/14	LAB COMPUT	PURC		$38.06
Actual	1/27/2015	P00448381612 IROBOT ROOMBA 4905 BATTERY	DUSLAN BAT	RPCC		$729.38
Actual	2/9/2015	P004491877BARREL PLUG CABLES	DIGI KEY	RPCC		$53.12
Actual	2/9/2015	P004491878ENCLOSURES FOR DC-DC POWER SUP	ITUNER NET	RPCC		$108.00
Actual	2/10/2015	P004482975ADVANCED POWER SYSTEM BATTERIE	IROBOT	RPCC		$230.84
Actual	2/10/2015	P004492845TAX CREDIT/REF: P#4482975	IROBOT	RPCC		($13.07)
Actual	2/18/2015	P004497455TRIP LITE DVI EQUALIZER/CABLE	AMAZON	RPCC		$90.78
Actual	2/20/2015	P004498545LOGITECH KEYBOARD AND MOUSE	AMAZON	RPCC		$39.74
Actual	2/26/2015	P004502868SEAGATE 2TB DESKTOP HARD DRIVE	AMAZON	RPCC		$399.95
Encumbrance	2/26/2015	HARD DRIVE MAILED TO IIT-INDIA	POST OFFICE	SRFC	10259047	$41.94
Encumbrance	3/2/2015	10259047 HARD DRIVE MAILED TO IIT-INDIA	POST OFFICE	SRFC	10259047	($41.94)
Actual	3/2/2015	10259047 HARD DRIVE MAILED TO IIT-INDIA	POST OFFICE	SRFC	10259047	$41.94
Actual	3/17/2015	P004508957BATTERY CHARGERS	AMAZON	RPCC		$117.53
Actual	4/2/2015	P004526571SUPPLIES FOR SMART ROBOT PROJE	AMAZON	RPCC		$345.94
Actual	4/2/2015	P004526569HOOKUP WIRE SILICONE CONNECTOR	MOUSER ELE	RPCC		$119.72

Actual	4/2/2015	P004526570MINI MAESTRO 24 CHANNEL USB	POLOLU COR	RPCC	$155.30
Actual	4/10/2015	P004530164SUPPLIES/BUIDING ROBOT NETWORK	SPARKFUN E	RPCC	$204.15
Actual	4/10/2015	P004530165LOSI MINI EIGHT SCALE TRUGGY	A MAIN HOBB	RPCC	$575.23
Encumbrance	4/15/2015	PR61037772	LAB EQUIPME	PURC	$6,132.00
Encumbrance	4/15/2015	PR61017100	LAB EQUIPME	PURC	$7,495.00
Actual	4/16/2015	P004537280RECHARGEABLE LITHIUM ION BATTE	BREN TRONI	RPCC	$1,844.54
Actual	4/17/2015	P004538242KNOWLES MICROPHONES/MOUNT FUSE	MOUSER ELE	RPCC	$591.23
Actual	4/17/2015	P004538241SEAGATE BACKUP PLUS 5TB DESKTO	AMAZON	RPCC	$158.75
Actual	4/20/2015	ROADNARROWPR61037772	LAB EQUIPME	PURC	$6,132.00
Encumbrance	4/20/2015	PO ATFO PR61037772	LAB EQUIPME	PURC	($6,132.00)
Encumbrance	4/23/2015	PR61286168	FABRICATED	PURC	$7,008.00
Actual	4/24/2015	P004540849UTILITY SHOVEL/TOOL BOX	THE HOME D	RPCC	$36.88
Encumbrance	5/1/2015	PO ATFO PR61017100	LAB EQUIPME	PURC	($7,495.00)
Actual	5/1/2015	ALICONA COPR61017100	LAB EQUIPME	PURC	$7,495.00
Actual	5/4/2015	P004547275BLADE NANO QX BNF QUADCOPTER	AMAZON	RPCC	$70.09
Actual	5/4/2015	P004544655BLADE NANO QX BNF QUADCOPTER	AMAZON	RPCC	$70.09
Actual	5/4/2015	P004545723HARD HIGH STRENGTH ALUMINUM	MCMASTER C	RPCC	$453.29
Actual	5/4/2015	P004547272BLADE NANO QUADCOPTER	AMAZON	RPCC	$70.09
Actual	5/4/2015	P004547274BLADE NANO QX BNF QUADCOPTER	AMAZON	RPCC	$70.09
Actual	5/4/2015	P004547276BLADE NANO QX BNF QUADCOPTER	AMAZON	RPCC	$449.95
Actual	5/4/2015	P004547273BLADE NANO QX BNF QUADCOPTER	AMAZON	RPCC	$70.09
Actual	5/5/2015	P004547277SUPPLIES FOR ROBOTS LAB	NATIONAL IN	RPCC	$1,951.15
Actual	5/5/2015	P004551092SUPPLIES FOR ROBOT LAB	AMAZON	RPCC	$126.49
Actual	5/5/2015	P004550010NANO QX PARTS BUNDLES	AMAZON	RPCC	$79.76
Actual	5/5/2015	P004550011MINI MAESTRO 24 CHANNEL USB	POLOLU COR	RPCC	$256.70
Actual	5/6/2015	P004551091TURIGY LIPO PACKS	PAYPAL U HO	RPCC	$74.91
Actual	5/6/2015	P004552558TAX CREDIT ON P#4552559	NVIDIA	RPCC	($93.00)
Actual	5/6/2015	P004552559JETSON TK1 DEVELOPMENT KIT	NVIDIA	RPCC	$1,642.95
Actual	5/6/2015	P004552556LOGITECH EXTREME 3D PRO JOYSTI	AMAZON	RPCC	$32.39
Actual	5/6/2015	P004552557THRUSTMASTER VG FERRARI WHEEL	AMAZON	RPCC	$67.40
Actual	5/12/2015	P004554168COMPACT LASER PRINTER	_AMAZON	RPCC	$119.98
Actual	5/14/2015	P004556236E FLITE CELECTRA 4 PORT CELL	AMAZON	RPCC	$126.38

Actual	5/14/2015	P004558299BATTERIES	DIGIKEY	RPCC		$61.69
Actual	5/14/2015	P004557613ALUMINUM CAPS/TERM BLOCK PLUG	DIGI KEY	RPCC		$48.77
Actual	5/19/2015	P004551093SUPPLIES FOR ROBOTS LAB	SPARKFUN E	RPCC		$519.25
Actual	5/20/2015	P004560278LOGITECH SPEAKERS	AMAZON	RPCC		$29.15
Actual	5/26/2015	P004565134CONNECTOR PLUG CRIMP/CONNECTOR	DIGI KEY	RPCC		$242.33
Actual	5/26/2015	P004564165EXCEED RC ELECTRIC INFINITIVE	AMAZON	RPCC		$270.38
Actual	5/26/2015	P004564163CRUCIAL 8GB NOTEBOOK MEMORY	AMAZON	RPCC		$57.95
Actual	5/26/2015	P004564162TWO OF MOTOR DRIVER CARRIER	POLOLU COR	RPCC		$53.85
Actual	5/26/2015	P004563249KNOWLES MICROPHONES	MOUSER ELE	RPCC		$1,320.80
Encumbrance	5/27/2015	A INCREASE	FABRICATED	PURC		$68.00
Encumbrance	5/27/2015	UNENC INCR	FABRICATED	PURC		($68.00)
Encumbrance	5/27/2015	PO ATFO PR61286168	FABRICATED	PURC		($7,008.00)
Actual	5/27/2015	ALLIGATOR PR61286168	FABRICATED	PURC		$7,076.00
Actual	6/1/2015	P004566116REFLECTIVE MARKERS/2 SIDED TAP	B&L ENGINEE	RPCC		$189.62
Actual	6/1/2015	P004565133JUMPER WIRES PREMIUM	SPARKFUN E	RPCC		$23.84
Actual	6/11/2015	P004576537SANDISK ULTRA 16GB COMPACT CAR	AMAZON	RPCC		$49.92
Actual	6/17/2015	ALICONA COPR52760782	ALICONA CO	PURC		$3,600.00
Encumbrance	6/17/2015	PO ATFO PR52760782	ALICONA CO	PURC		($3,600.00)
Actual	6/22/2015	P004580815BOOK FOR ROBOTICS & SENSOR LAB	AMAZON	RPCC		$33.20
Actual	6/22/2015	P004580816BOOKS FOR RESEARCH	AMAZON	RPCC		$126.31
Actual	6/25/2015	E14081709	Lab supplies	EBUY		$96.96
	Total For FABRICATED CAP EQUIP			**$152,001.70**		

0710 EQUIP> $5000

Encumbrance	12/18/2013	PR45835115-END DATE: 7/31/2014	VICON DENV	PURC		$27,137.00
Encumbrance	3/10/2014	PO ATFO PR45835115-END DATE: 7/31/2014	VICON DENV	PURC		($27,137.00)
Encumbrance	3/10/2014	UNENC INCR	VICON DENV	PURC		($200.00)
Actual	3/10/2014	VICON PR45835115-END DATE: 7/31/2014	VICON DENV	PURC		$27,337.00
Encumbrance	3/10/2014	A INCREASE	VICON DENV	PURC		$200.00
Encumbrance	4/30/2014		ROBOTICS LA	JVDP	9905241	($27,337.00)
Actual	5/1/2014	09905241	ROBOTICS LA	JVDP	9905241	($27,337.00)
Encumbrance	5/1/2014	09905241	ROBOTICS LA	JVDP	9905241	$27,337.00
	Total For EQUIP> $5000 :			**$0.00**		

0901 CONTRACT RES - SPEC

Actual	10/8/2013	FO:OVHD		JVFO		$2,361.70
Actual	10/15/2013	FO:OVHD		JVFO		$856.79
Actual	12/16/2013	FO:OVHD		JVFO		$308.88
Actual	12/20/2013	FO:OVHD		JVFO		$278.44
Actual	1/17/2014	FO:OVHD		JVFO		$4,445.50

Actual	2/13/2014	FO:OVHD	JVFO	$714.63
Actual	2/26/2014	FO:OVHD	JVFO	$184.64
Actual	3/10/2014	FO:OVHD	JVFO	$2,478.96
Actual	5/1/2014	FO:OVHD	JVFO	($11,629.54)
Actual	8/1/2014	FO:OVHD	JVFO	$44.86
Actual	8/11/2014	FO:OVHD	JVFO	($44.86)
Actual	11/19/2014	FO:OVHD	JVFO	$309.24
Actual	1/19/2015	FO:OVHD	JVFO	$1,339.98
Actual	1/20/2015	FO:OVHD	JVFO	$394.87
Actual	1/28/2015	FO:OVHD	JVFO	($1,339.98)
Actual	2/3/2015	FO:OVHD	JVFO	$394.87
Actual	2/16/2015	FO:OVHD	JVFO	$551.54
Actual	2/17/2015	FO:OVHD	JVFO	$394.87
Actual	3/3/2015	FO:OVHD	JVFO	$394.87
Actual	3/16/2015	FO:OVHD	JVFO	$715.51
Actual	3/17/2015	FO:OVHD	JVFO	$394.87
Actual	4/1/2015	FO:OVHD	JVFO	$394.87
Actual	4/3/2015	FO:OVHD	JVFO	$2.56
Actual	4/14/2015	FO:OVHD	JVFO	$791.27
Actual	4/29/2015	FO:OVHD	JVFO	$775.14
Actual	5/2/2015	FO:OVHD	JVFO	$498.92
Actual	5/12/2015	FO:OVHD	JVFO	$493.97
Actual	5/13/2015	FO:OVHD	JVFO	$212.17
Actual	5/19/2015	FO:OVHD	JVFO	$666.35
Actual	5/22/2015	FO:OVHD	JVFO	$394.87
Actual	6/9/2015	FO:OVHD	JVFO	$394.87
Actual	6/22/2015	FO:OVHD	JVFO	$491.92
Actual	6/23/2015	FO:OVHD	JVFO	$394.87
Actual	6/30/2015	FO:OVHD	JVFO	$5,323.57
Actual	6/30/2015	FO:OVHD	JVFO	$394.87
	Total For CONTRACT RES - SPEC		**$14,780.86**	

ACCOUNT SUMMARY

Income

Budgeted Income:	$200,000.00
Income Rec'd to Date:	$171,381.35
Income Due:	$28,618.65

Expense:

Total Budget for Account:	$200,000.00
Actual Expenses:	$196,642.89
Encumbered Expenses:	$11,726.50
Balance, without Fringe and Overhead Calculations:	($8,369.39)
ACCOUNT BALANCE, WITH FRINGE AND OVERHEAD CALCULATIONS:	**($15,367.20)**